

## Development of a tanks line for waxing landing gear parts

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**Abstract** The aim of this article is to define the technical specifications and to design the implementation of a line of tanks that would be used in the process of waxing and de-waxing large pieces. As it is based in a real case, it is also analyzed the process of dismantling the former installation that supported these functions. The origin of this project is due to a new rating for the maintenance of landing gears which makes the previous waxing line that was prepared to work on smaller aircraft's pieces, no longer adequate to the current workflow and processes.

**Keywords:** Maintenance organization, tanks line, waxed, reengineering, landing gear

### 1.1 Introduction

The waxing line is located in an aircraft maintenance workshop that, as an aircraft maintenance organization, holds the certificate of the European Aviation Safety Agency (EASA), part 145. This certificate specifies the requirements that need to satisfy any organization dedicated to the maintenance of large aircrafts or to commercial transportation, as well as the components that need to be installed in those aircrafts.

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The maintenance workshop has to perform every operation according to its manual of Maintenance Organization Exposition (MOE). This document contains all the tasks that the workshop is allowed to develop, the used procedures, the list of certifying staff, the resources and facilities description, and the list of commercial stakeholders and subcontractors. A Part 145 Organization has the obligation to keep all the information related to every maintenance task performed on the aircraft or its components, at least during the following two years to the accomplishment of the task.

## **1.2 Project facilities and implementation**

The objective of this project is to adapt the wax section to a new ability level and to the current legislation. These abilities come from a new agreement for the maintenance of landing gears that belong to Airbus' aircrafts, mainly to the group A320 but there will also be kept some units per year of landing gears that belong to the A340 fleet. The agreement involves the formation of a partnership with an Asian company and it represents a significant production increase for the next 15 years, whose main tasks are processes of electrolytic and machining baths with the grinding. All this makes the old waxing line qualitatively and quantitatively inadequate to the volume of work, as well as to the new processes that need to be carried out. Because of this, it is needed a redesign and restructuring of certain divisions inside the engines' workshop, which is in charge too of components such as MSG, APU (auxiliary power unit). This workshop is composed of 20 people that are distributed up to 900 m<sup>2</sup>. The different phases that shape the group of scheduled maintenance tasks, and that should be completely defined in the Component Maintenance Manual (CMM) to perform on the landing gear, excluding the assembly-disassembly and release of subsystems are: cleaning, inspection and repair.

The waxing is developed for the coverage of pieces that need to be chromed and cadmium plated. The usual processes are hard chromes, more than re-growth, for the bearing contact area. Therefore, the wax is necessary for the execution of the different tasks of the new agreement. Moreover, the latest changes in the rules require the development of the tank line without trichlorethylene (TCE), as its use has been banned. For a correct application of the wrapping wax, is important to take into account different factors such as: physical properties of the raw material (wax), size of the pieces, preconditions of the pieces to be treated, environmental conditions, etc.

### 1.3 The process of remodeling the wax baths

Under the new plant distribution of the engine workshop, the location of the current mechanical-cleaning division will now be placed where the landing gears were processed. At the same time, the equipment of the current line VIII of the Electrolytic Baths sections will be restructured, replacing tanks from 111 to 118 due to functionality and occupation reasons, as shown in Figure 1.1. This line performed the process of decorative chrome. At the place left free, the six tanks that make up the new waxing line will be placed together. Three of those tanks will be new and the other three will be reused from the Chemical Cleaning Division, since here the tanks can't be used as the division is not prepared to absorb the generated vapors and because it will make the staff work out from their own divisions (which violates the workplace safety standards). The new configuration requires the complete dismantling of all the mentioned tanks and a huge reform of the structure that supports the tanks and the corridors. There will be changes required too in the some of the general installations (electrical, suction, water, drainage and compressed air), in order to adapt them to the new policy and use. The tasks will be performed by the manufacturer of the waxing line, and may need the support of another company. Because, for example, the dismantling tasks require having in the workshop the proper lifts (hoist and crane). The process will consists in different phases: dismantle of the tanks 111 to 118; displacement and removal to an enabled area of the remains for its later disposal, but only if they are not useful for the next phase (3 cleaning tanks); plug pipes and connections where feasible; electrical disconnection of the facility, as well as the fluid connections; decontamination and disposal of contaminant remains and certification in accordance with the current regulations; and cover temporarily the empty space left in the floor after the dismantling of the tanks.



**Fig. 1.1** Old waxing line

Among the disassembly and assembly there will take place an intermediate phase of adaptation of the structure of the basement, as well as the adaptation of the suction networks, steam line and all those support systems of the division. The work will be carried out in the electrolytic baths section, where the installation company will have qualified staff and its own machinery, and among them are:

1. The polyester and metal tanks will be downloaded and carried to the workshop.
2. It will be necessary to develop a plan to move the tanks inside the baths' division. This plan is based on the data provided by the company owner of the maintenance workshop, which is  $1.000 \text{ kg/m}^2$  on the estimated burden of the existing wrought in the section prior to the work done by the installation machinery. Form the analysis is deduced that the resistance of the corridor needs to be increased by placing metal struts with at least  $2.000 \text{ kg}$  of capacity of vertical support, and placing at least 4 struts per  $\text{m}^2$ .
3. The tanks to be installed have a minimum weight of  $1.800 \text{ kg}$  and a maximum weight of  $3.200 \text{ kg}$ . Their base varies from  $2 \times 1,5 \text{ m}$  of the lightest tank to  $2.5 \times 2 \text{ m}$  of the heaviest tank (wax tank).
4. The tanks will be introduced one by one. And each one will be placed in its final position.
5. From the automatic exterior door of the section, each tank will be lifted and placed vertically on the beginning of the aisle of the section. Each tank will be placed over four small tanks and it will be pushed towards the beginning of the hole of line VIII. Then an electrically auto propelled spider crane will move to that place. It will display its four legs, leaning each one on plates of  $2 \times 1 \text{ m}$  and  $1 \text{ cm}$  thick in order to spread the load. The surface developed by the spider crane with its displayed legs is of  $33 \text{ m}^2$ .
6. Each tank will be hoisted with special large tonnage polyester slings, and will be placed at the beginning of the bench in the basement.
7. Once the tank is placed over the rails of the bench, the slings will be removed, the crane will be disconnected and the tank will move to its final position. Then the crane must fold its legs so free space is left for the next tank to come in.
8. This process must be repeated with each of the tanks.

## **1.4 Design and construction of the line**

We are going to analyze the preliminary design and installation of the line, attending to the function to perform, the use and available resources and its construction. First of all, is important to explain the choice of the waxing as the most appropriate process for masking pieces versus any other alternatives such as the projection of paint, the use of SERMETEL, or the use of sticky tapes.

The projection of paint was discarded because the projection process needs pre and post-processes such as layer removing, paint projection... Furthermore, the

projection of paint is complicated in pieces with holes. The use of sticky tapes is not useful because of the complicated taping and because the electrolytic treatments could unstick the tape. The SERMETEL is a better option because this procedure involves the application of a ceramic composite coating which protects the piece against corrosion, thermal shock, electrolyte and chemical attack, and can be applied on steel, iron, nickel, titanium and their alloys. This option has against: the need of a projection SERMETEL cabin of high costs and a difficult and inefficient application, especially for geometrically complex pieces. As most of the pieces that will be treated are landing gears, and they have this complexity, this option was dismissed.

Due to all these facts the waxing system was elected, as it adapts much better to all the requirements and with a lower investment. It should be highlighting the importance of a good equipment design, heating systems, maintenance plan, procedure for checking the tanks, etc., in order to maintain the costs of the processes at an acceptable quality, and efficiency economic level.

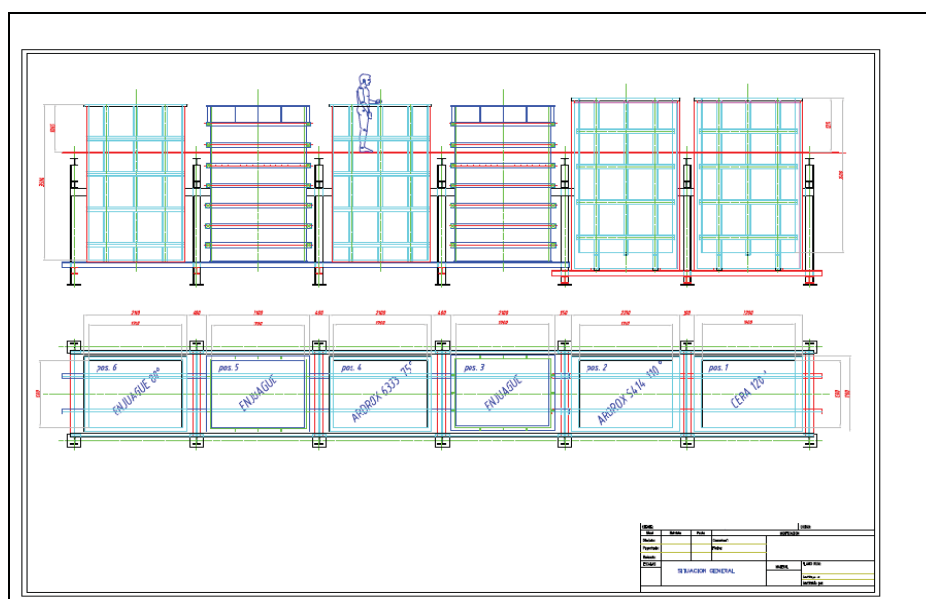
Basically we will find a chemical cleaning line, with the exception of the wax tank placed at position 1 and the de-waxing tank placed at position 2. The positions needed are: 1st for the tank of wax application, 2nd for the de-waxing tank, 3rd for the rinse tank with de-waxing products, 4th for the degreasing tank, 5th for rinsing tank of the degreaser product, 6th for final rinse tank.

To remove the wax in the old installation a standard industrial chemical cleaning process was applied a degreasing process. The degreasing products belong to the family of chlorinated solvents and within these the trichloroethylene was used, which has some limitations (OSHA limits: parts per million allowed in the air during a working day of 8 hours in the American Organization of Health and Safety. Odor limit in PPM: parts per million that must be in the air to make and odor perceptible by man). This solvent has a very high vapor pressure so it transforms to vapor very easily, even at room temperature, and it is highly reactive, which makes its use undesirable being normally replaced in order to fulfill these functions by configurations as the one projected in this study. For the rinses and the rest of the tanks which need water, de-mineralized water (and therefore ionized) is used. This water will be of a high purity. It won't be necessary a previous distill to correct the pH, since the water from the supply network of the workshop has a great quality with a pH = 7.

The choice of the materials for the construction of the tanks responds to the combination of the following two factors: the need of thermal insulation of the tank, and the possibility of a chemical attack by the agent that contains the tank (mainly acids). Both factors make that the tanks with thermal insulation shall be made up of stainless steel, with the possible exception that some ARDROX product could oxidize the steel, in this case the PPH (high density polypropylene) will be built.

In our case, using ARDROX 5414 and 6333, steel can be used except in the non-lagged.

The dimensions of the tanks are determined by factors such as: dimensions of the pieces to be processed; capacity to contain the adequate quantity of wax in order to avoid a sudden cooling of it when the piece is introduced; capacity to contain the necessary quantity of chemical products or water so that the processes carried out in each tank are performed effective and adequately; large enough to accommodate the stirring and heating systems of the liquid wax, to optimize the jobs' ergonomics, material economy, minimum expenditure of electrical energy, water, steam and chemical products, and the process performed in each tank. All these factors lead to the following interior dimensions of: 1.900 mm length, 1.500 mm width, and 3.500 mm height. The external dimensions depend on each of the tanks. Each tank is divided into 3 areas: lower or heating area, intermediate or degreasing area, and upper or condensing area and auxiliary equipment. The tanks' lids, due to its high weight, will need a pneumatic opening system with a manual control for the operator. It is necessary to reform entirely the old ventilation and aspiration duct, but only in those tanks that contain products which by their nature or temperature can produce gases. In those cases, a new ventilation and aspiration duct, already adapted to the new requirements and dimensions, needs to be set up. It will be built entirely in PPH, from the ventilator mouthpiece to the derivations required for each position. The definition of the installation is shown in Figure 1.2.



**Fig. 1.2** General arrangement of the line

All this leads to a waxing line with the following definition:

- Position 1: Waxing process (120°C).
- Position 2: Ardrox process (110°C, de-waxing).
- Position 3: Rinse process (room temperature).

- Position 4: Ardrox process (75°C, cleaning and degreasing).
- Position 5: Rinse process (room temperature).
- Position 6: Rinse process (80°C).

## 1.5 Project costs

The most important expenditure item belongs to the tasks of removal, installation, adaptation and to the value of the equipment that make up the line. 153.000 € is the amount that corresponds to the equipment and installation, and 5.560 € is the amount of dismantling of the old line. The operating expenses include:

1. Staff: estimated at 200.000 €/year fixed with 2% of estimated inflation.
2. Power consumption: estimated at 60.000 €/year.
3. Water consumption: estimated at 8.000 €/year.
4. Crude wax and caloric oil: estimated at 17.115 €/year.
5. Ardrox solvents: estimated at 23.650 €/year.

Different studies estimate that 8% of the costs are due to chemical products in the process. The remaining 92% belongs to electricity, labor, maintenance, heating, washing water, purification and waste treatment, financial costs and control costs. The investment ends up profitable applying the VAN and TIR criteria. Furthermore, the payback is 3 year.

## 1.6 Processes and procedures to implement in the MLG

In order to standardize in a single numerical code all the aircraft's systems, the ATA (Transport Association of America) established a 100 based code that is commonly accepted by the industry and the aeronautical authorities. The ATA 32 corresponds to landing gears, and therefore all the manuals of the aircraft and its components develop organized by this code. Although in the waxing line some tasks are performed on various elements of the MLG, the study focuses in the most significant piece, which is the main body of the MLG. The differences between the diverse MLG of aircrafts of the group A320 are not significant, so everything is about the A320 (its PN is 201371). The weight of the whole set after being filled with hydraulic oil is about 425 kg (940 lb). The MLG is a retractable system that consists of a 2-stage damper of hydro-pneumatic and retractable action towards the inside of the fuselage. Its structure consists of a main body with a buffer over the one a pipe with an axis for 2 wheels slides. The binding of the tube to the body is through peer links. It is built in MAT 135 or 35NCD16THQ steel, a stainless steel which after a thermal superficial treatment acquires great mechanical and corrosion strength. The piece measures 75 cm long and 33 cm wide. The



operation will need to be performed every 10 years or after 20.000 landing-takeoff cycles, that means two times in the useful life of a plane belonging to IATA. Once it is known the work to be performed, where and when, it is necessary to know the correct execution of the tasks that includes the work, which is referenced in the CMM.

## **1.7 Conclusions**

All conclusions provided here come from the experience in the installation of the wax line, after its startup in May 2011. The line has been working almost without interruption, obtaining acceptable operating results.

There are some problems in the opening lids system, which can be solved by implementing shorter double rod pneumatic cylinders. Another problem is the PT probes which are located in the corner formed by the side and front wall of the tank, as this is the most suitable place for review and installation tasks, but having the disadvantage of leaving the thermocouple very exposed to impacts during the use of the line. Metal grates can be placed around the probe to protect it. Due to the technical and economical complexity of developing a new supply network of compressed air, is important to consider this limitation at the time of scheduling the workload.

Different studies estimate that in a regular chemical cleaning process, the spending on chemical products does not exceed 10% of the total cost, but in this case it rises to 15%.

Reengineering is the enemy of gradual changes, and this concept can be applied perfectly to this project as it requires a complete redefinition of the facility and the procedures that need to be used.

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